Interoperability
Towards a system approach for urban flood risk management

urban flood resilience

FACTSHEET

Project area: *Design for exceedance, system of systems*
Intended audience: *Researchers, practitioners, general public*

Introduction

Urban areas contain multiple infrastructure systems (e.g. roads, land use, energy) and in each system stormwater management options exist (e.g. permeable roads, retention ponds, dams). Yet, the ability of these systems to interact – or interoperate – with each other to enhance the overall capacity of the system to manage stormwater is not well understood. Actively managing these interactions could increase the functionality of flood risk management designs and produce gains in efficiency while reducing costs. This factsheet presents the concept of interoperability as a means to develop a general framework to guide application of more "whole system" urban flood risk management.

The urban challenge: a system of systems

An urban environment can be considered a "system of systems" [1] (Fig. 1), where limited space, competing demands, and strong interdependencies between infrastructure systems imply that multifunctional and flexible adaptation measures are fundamental to making urban communities more resilient to the adverse impacts of flooding as well as climate change and urbanisation [2,3].

Many options exist for flood risk management (FRM) (Fig. 1). For example, multifunctional Blue and Green designs, which aim to use natural processes to manage excessive water (e.g. increasing infiltration and storage) and water quality, while also providing additional environmental and health benefits (e.g. reducing air pollution).

Yet, despite the growing number of multifunctional options for FRM, it remains difficult to fully integrate them into urban infrastructure systems and to understand how connecting Blue-Green infrastructure with other urban systems (e.g. transport or land use) can expand the capacity of the overall system towards achieving urban flood resilience [4]. For example, the way Blue-Green infrastructure can protect against flooding is often restricted by the availability of space and the timescale of events, and dependent on other systems (e.g. roads for runoff) [2]. Therefore, an important aspect of the transformation to greater urban flood resilience, is to adopt a holistic approach to FRM. But, despite widespread recognition of this need, it is challenging to implement a systems approach in practice [5]. To this end, interoperable systems of Blue-Green and Grey infrastructure for FRM with other urban infrastructure systems present a possible practical solution (Fig. 1).

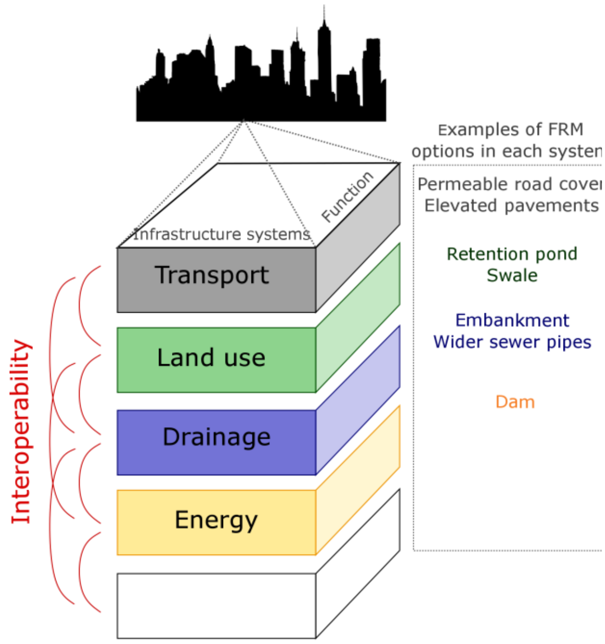

Figure 1: *The city consists of multiple infrastructure systems, having multiple functions. In each system, options exist for flood risk management (FRM), creating possibilities of interoperability between systems to enhance to overall system capacity to deal with excess stormwater.*

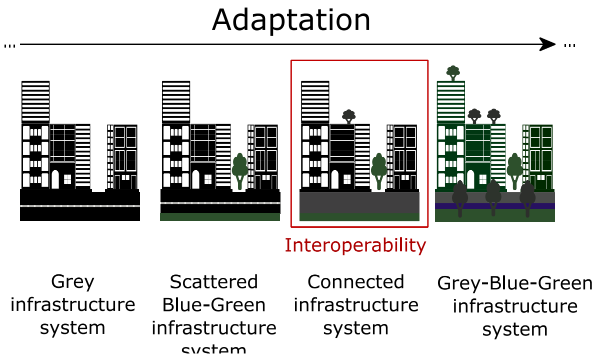

Figure 2: *Interoperability as part of adaptation process from grey infrastructure to resilient Blue-Green cities.*

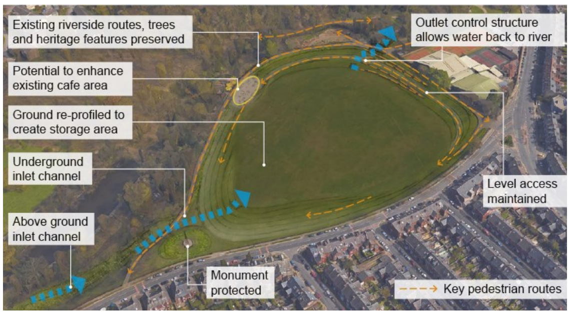

Figure 3: *Example of a potential drainage-green infrastructure interoperability at Endcliffe Park. Sheffield.*[6]

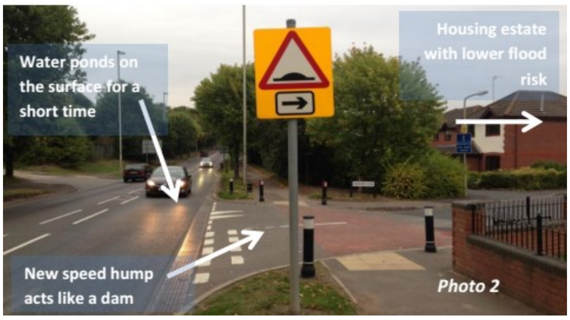

Figure 4: *Example of a road-drainage interoperability in Dudley Metropolitan Borough Council.* [7]

Defining interoperability for flood risk management

In this project, interoperability is considered as part of an ongoing adaptive process towards system-based FRM and wider urban development[5] (Fig. 2). Implementation of interoperable solutions focuses on interventions that enhance the functioning of water management systems by actively managing linkages with other urban systems: *"Interoperability is the ability of any water management system to redirect water and make use of other system(s) to maintain or enhance its performance function during exceedance events."* In what follows, the concept of interoperability for FRM is further illustrated with two examples.

(i) Drainage & land use interoperability

Improving connectivity between the drainage network and land use features creates opportunities to transfer the drainage function from the (piped) drainage system to, for example, Blue-Green infrastructure. Fig. 3 shows an example of a proposed interoperable system whereby Endcliffe Park in Sheffield is converted to a potential retention basin through creating an embankment and increasing the connectivity between the water system and the green infrastructure.

(ii) Drainage & transport interoperability

In the absence of any Blue-Green infrastructure, or to potentially connect two disconnected systems, the (piped) drainage network can also be directly connected to the transport network to divert and transfer storm water during storm events. In Fig. 4, this is illustrated with an example from Dudley Metropolitan Borough Council. A speed hump and earth bund redirect water away from residential houses towards the highway for temporary storage.

This factsheet is the first in a series to document the development of an investigative approach into interoperability in managing urban flood risk at case study sites in the UK.

References:

[1] Zevenbergen, C., et al. Challenges in urban flood management: travelling across spatial and temporal scales. J. Flood Risk Manag. 1, 81–88 (2008). [2] Hoang, L. & Fenner, R. A. System interactions of stormwater management using sustainable urban drainage systems and green infrastructure. Urban Water J. 13, 739–758 (2016). [3] Balmforth, D., et al., Designing for exceedance in urban drainage - good practice. (CIRIA, 2006). [4] Ernst, K. M. & Preston, B. L. Adaptation opportunities and constraints in coupled systems: Evidence from the U.S. energy-water nexus. Environ. Sci. Policy 70, 38–45 (2017). [5] Collier, M. J. et al. Transitioning to resilience and sustainability in urban communities. Cities 32, (2013). [6] Sheffield City Council. Endcliffe Park flood storage area. (2018). [7] Digman, C. et al., Managing urban flooding from heavy rainfall - encouraging the uptake of designing for exceedance. Case studies. (CIRIA, 2014).

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